by a trustworthy observer, seems to imply a discharge over a total length of nearly ten miles.

When a tree is struck by a violent discharge it is usually split up laterally into mere fibres. A more moderate discharge may rupture the channels through which the sap flows, and thus the tree may be killed without suffering any apparent external damage. These results are usually assigned to the sudden vaporisation of moisture, and the idea is probably accurate, for it is easy to burst a very strong glass tube if we fill it with water and discharge a jar by means of two wires whose extremities are placed in the water at a short distance from one another. The tube bursts even if one end be left open, thus showing that the extreme suddenness of the explosion makes it act in all directions, and not solely in that of least resistance. When we think of the danger of leaving even a few drops of water in a mould into which melted iron is to be poured, we shall find no difficulty in thus accounting for the violent disruptive effects produced by lightning.

Heated air is found to conduct better than cold air, probably on account of the diminution of density only. Hence we can easily see how it is that animals are often killed in great numbers by a single discharge, as they crowd together in a storm, and a column of warm air rises from the group.

Inside a thundercloud the danger seems to be much less than outside. There are several instances on record of travellers having passed *through* clouds from which, both before and after their passage, fierce flashes were seen to escape. Many remarkable instances are to be found in Alpine travel, and specially in the reports of the officers engaged in the survey of the Pyrenees. Several times it is recorded that such violent thunderstorms were seen to form round the mountain on which they were encamped, that the neighbouring inhabitants were surprised to see them return alive.

Before the use of lightning-rods on ships became general great damage was often done to them by lightning. The number of British ships of war thus wholly destroyed or much injured during the long wars towards the end of the last and the beginning of the present century is quite comparable with that of those lost or injured by gales, or even in battle. In some of these cases, however, the damage was only indirectly due to lightning, as the powder magazines were blown up. In the powder magazine of Brescia, in 1769, lightning set fire to over 2,000,000 lbs. of gunpowder, producing one of the most disastrous explosions on record.

A powerful discharge of lightning can fuse not only bell wires, but even stout rods of iron. It often permanently magnetises steel, and in this way has been the cause of the loss of many a good ship; for the magnetism of the compass-needles has been sometimes destroyed, sometimes reversed, sometimes so altered that the compass pointed east and west. And by the magnetisation of their steel parts the chronometers have had their rates seriously altered. Thus two of the sailor's most important aids to navigation have been simultaneously rendered useless or, what is worse, misleading; and this, too, at a time when, because of clouds, astronomical observations were generally impossible. All these dangers are now, however, easily and all but completely avoidable.

A very singular effect of lightning sometimes observed is the piercing of a hole in a conducting-plate of metal, such as the lead-covering of a roof. In such a case it is invariably found that a good conductor well connected with the ground approaches near to the metal sheet at the part perforated.

(*To be continued.*)

HUMAN HYBERNATION

DR. TANNER is scarcely off the field when another physiological wonder breaks out in the form of a sleeping girl of Grambke, near to Bremen. This young lady lies, it is said, in a profound slumber night and day, resting on her left side and never asking for food, but swallowing liquid food when it is put into her mouth. The trance lasts an average of fifty days, during which time she is pale, but does not lose in weight. Her sleep is not cataleptic in the proper sense of the term, inasmuch as she is sufficiently conscious to swallow, and presents none of the indications of death. She merely sleeps. Instances of this kind are not so uncommon as those of true catalepsy, though some of them are sufficiently remarkable. In the *Transactions* of the Royal Society Dr. W. Oliver has recorded the history of an extraordinary sleeping person named Samuel Chilton of Tinsbury, near Bath, who, on May 13, 1694, being then "of robust habit of body, not fat, but fleshy, and a dark brown hair," happened, without any visible cause or evident sign, to fall into a very profound sleep, out of which no art used by those who were near him could rouse him until after a month's time; then he rose of himself, put on his clothes, and went about his business of husbandry as usual; slept, could eat and drink as before, but spoke not one word till about a month after. In 1696, on the 9th of April, this youth fell off to sleep again, and although a heroic apothecary, Mr. Gibbs, bled him, blistered him, cupped him, and scarified him, he slept on for seventeen weeks, waking up on August 7, not knowing he had slept above a night, and unable to be persuaded he had lain so long, until going out into the fields he found everybody busy getting in the harvest, and then remembered very well that when he fell asleep they were sowing of the barley and oats which he now saw ripe and ready to be cut down. For six weeks of this sleep he had fasted, but after he awoke he went to work in his ordinary way, and continued to work until August 17, 1697, when, after complaining of shivering and cold in his back, and vomiting once or twice, he fell into one of his long sleeps once more, and being visited by Dr. Oliver and many others, was subjected to further bleeding and extremely sharp treatment indeed, but without being roused. So he lay sleeping until November 19, when he awoke, said he "felt very well, thank God," ate some bread and cheese, and dropping off still another time, slept on until the end of January, 1698, and "then waked perfectly well, not remembering anything that happened all this while." He was observed to have lost flesh, but only complained of being pinched by the cold, and presently fell to husbandry as at other times. The known phenomenon that is nearest to this is hybernation in some of the inferior animals; but it is worthy of remark that the persons affected take food unconsciously when it is offered them, the lower nervous centres seeming to remain in a continued state of activity.

PHYSICS WITHOUT APPARATUS[1]

III.

THE laws of the behaviour of liquids, their pressure and their flow, are very readily demonstrated without special apparatus by the aid of simple articles of everyday use. First amongst the laws of liquid pressure comes the all-important principle that the pressure exerted by a liquid at any point is proportional to the depth, below the surface, of the point under consideration. This pressure is exerted upwards or downwards according to circumstances. We can show first a case of pressure exerted in an upward direction. Take the glass chimney of a lamp, that of a paraffin-lamp will answer, though the straighter form of chimney used in an Argand or a Silber lamp is preferable. Cut out with a pair of scissors a circular disk of stout cardboard, and attach a thread to it by means of a drop of sealing-wax. Provide yourself also with a deep dish of water. Such a glass trough as is used for a drawing-room aquarium will answer capitally for this purpose; but if no deep glass vessel is available, a pan or tub of stone-ware or of tin-ware will serve the purpose. The disk of card should be pressed against the lower end of the lamp-chimney (as in Fig. 8) by pulling up the thread through the glass tube. If it is then lowered into the water in the glass trough, the upward force of the water outside pressing up against the card disk will keep it against the end of the lamp-glass. The deeper it is plunged the more tightly is it pressed up against the end of the tube, for the pressure of the liquid becomes greater and greater as the depth of the disk below the surface is increased. A case of downward pressure is even more simply shown. Take the lamp-chimney in your hand and hold it vertical as before, and fix to the lower end another disk of card, this time fixing it to the bottom of the glass by means of soft bees'-wax or of a little stiff tallow. Now pour in some water from above. At first the disk is held on by the wax, and you may pour in water until the chimney is perhaps half full. But as you go on pouring in water the depth of the water inside gets greater and greater, and the pressure exerted by the column of liquid becomes also greater, until the adhesive force of the wax is overcome, and the water bursts off the card and rushes out. This second experiment may be combined with the first one, as is shown in Fig. 8. After having lowered the empty lamp-chimney closed by the card disk into the trough of water, slowly pour in water into the inside. As long as the level of the water *outside* is higher than that of the water inside, the outer pressure upwards will be greater than the inner pressure downwards; but as soon as enough water has been poured in to raise the inner level to that outside, the internal and external pressures will be equal, and when a few more drops are added inside the card will be forced away. The fact that liquid pressure depends upon the height of the column of liquid that is pressing, is made familiar to us in the arrangements for supplying our houses with water; for when the cistern is at the top of the house we find that on opening a tap in a lower storey the water rushes out with very great force, so great, perhaps, that we cannot possibly stop it with our hand, however tightly we press it against the mouth of the tap.

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[1] Continued from p. 345.

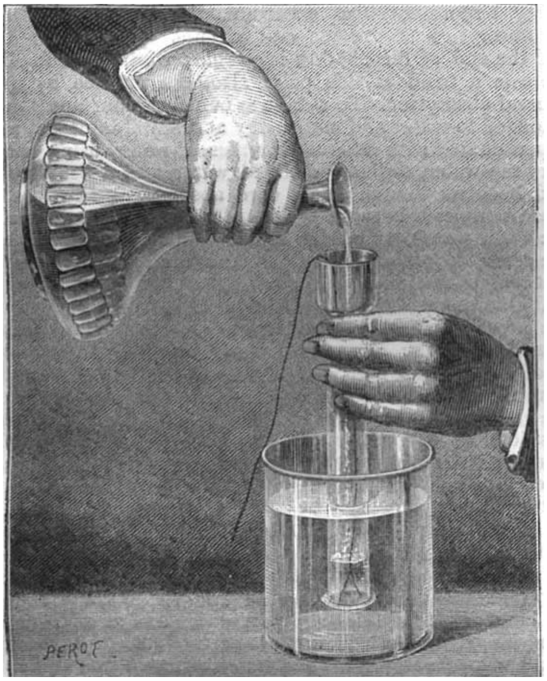

FIG. 8.

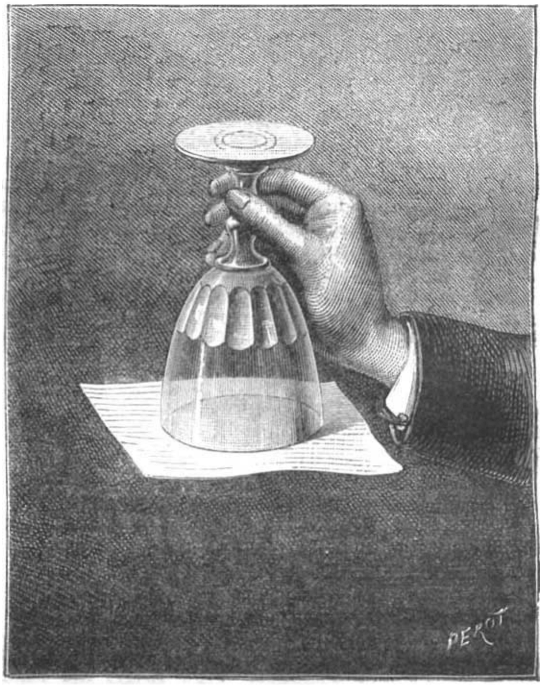

FIG. 9.

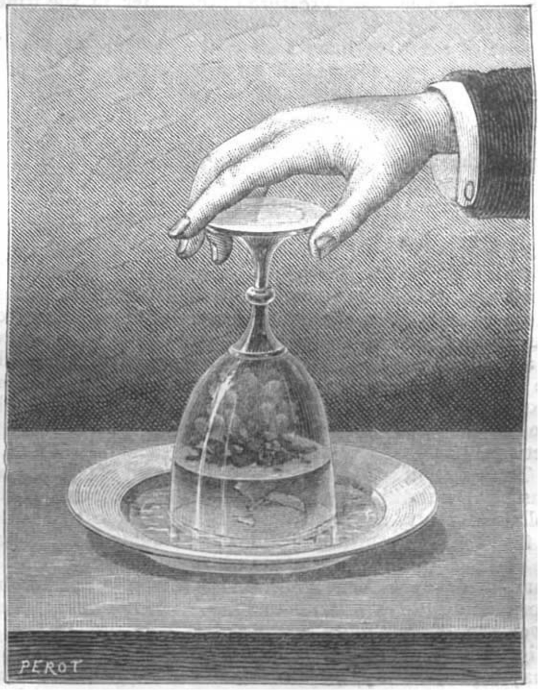

FIG. 10.

Another important law of liquid pressure, not so easy of illustration without apparatus, is the famous principle of Pascal, that when a liquid is put into a closed vessel, and then subjected at any point to a pressure, this pressure is transmitted equally in all directions. If the vessel be a strong one and provided with two movable pistons, a large and a small one, the area of the large piston being many times as great as that of the small one, any pressure exerted upon the small piston to the liquid will be transmitted equally over equal amounts of surface, and hence the total pressure on the large piston will be many times as great as the original force, just in proportion as its area is greater than that of the small piston. This is, in fact, the principle applied in the hydraulic press of Bramah and in the hydraulic machinery of Sir W. Armstrong, by which heavy bridges, dock-gates, and elevators are set in motion. The writer of this article, when sore-pressed to devise an experimental illustration of the principle of the hydraulic press, contrived the following arrangement. The lid of a coffee-pot was removed and a piece of sheet-indiarubber was tied tightly over the open top. Into the spout a piece of lead-pipe about six feet long was inserted, firmly fixed with sealing-wax, and then turned up vertically. The pot was filled with water, and a heavy book placed upon the top. Water was poured into the lead tube until it was filled up to the top. A column of water six feet high affords a pressure of nearly three pounds per square inch, and this, exerted over the whole area of the rubber-covered top, gave a sufficient total pressure to raise the heavy book.

The air also possesses weight, and exerts a pressure which may be upwards or downwards according to circumstances. Let a wine-glass or a tumbler be filled full of water and a thin card laid upon the top of it, so that bubbles of air are excluded. Now invert the whole, pressing the card lightly on to the glass during the operation, to prevent accidents, and it will be found (see Fig. 9) that the water will remain in the wine-glass, and will not fall out. In fact the pressure of the air upwards against the card is much more than sufficient to counterbalance the downward pressure of the water in the wine-glass.

Most of the experiments upon the pressure of the air require, however, the aid of an air-pump for their performance. With the air-pump a large variety of interesting properties of the air can be demonstrated, which otherwise cannot be shown. A few, however, do not require the aid of this instrument. The effect of the external pressure of the air in raising the level of a liquid in a tube from which the air has been partially exhausted, thereby reducing its pressure, can be shown by sucking with the mouth at the top of a glass tube, the lower end of which dips into the liquid in question. Thus it is possible to suck up mercury to a height of fifteen inches into a tube; for the lungs are strong enough to reduce the air in the tube to about half the ordinary pressure. If a glass tube of sufficient length were available it would be possible to suck up water in it to a height of about sixteen or seventeen feet; for a column of that height would be sufficient to counterbalance the difference between the inside and outside pressures.

The rising of a liquid into a space from which the air has been partially removed may also be illustrated in the following pretty way. Take a small bit of card and let it float upon the surface of water in a shallow dish. Upon it place a few shavings of wood and light them with a match; or place a small red-hot coal upon it, and on this sprinkle a little brimstone to burn. Then quickly invert over the blazing mass a wine-glass or a tumbler, as in Fig. 10. As the shavings or the brimstone, as the case may be, burn away, they withdraw the oxygen of the air inclosed in the space above, until only the nitrogen (about four-fifths of the whole) remains. The gases inside, therefore, will not exert so great a pressure as before, and consequently the pressure of the air outside will force the water to rise in the glass as the remaining gases cool down to the temperature at which they were at first.

(*To be continued.*)

ON THE ABSORPTION BANDS IN CERTAIN COLOURLESS LIQUIDS

[PRELIMINARY NOTICE]

HAVING occasion to examine the absorption spectra produced by considerable thicknesses of alcoholic solutions of certain cobalt salts, we were led accidentally to observe that alcohol alone gave a very distinct band, and afterwards, on examining water, found that it also, when a column of six feet was used, gave a very distinct absorption band in the orange, a little on the less refrangible side of D. By graphical interpolation we find the centre of this band to be about 600, and that the band extends from 607 to 596. This position corresponds very closely, if it be not identical, with Piazzi Smyth's rain band,[1] and also with the band seen in 330 feet of high-pressure steam by Janssen.[2]

Fig. 1 represents this spectrum. It will be seen that the absorption at the red end extends up to the line C, and the end of the shadow is so sharp that it is probable there is a band at this point also, but masked by the general absorption. To convince ourselves that this band belonged to water and not to any accidental impurity, we experimented with different samples of water, using ordinary tap-water, ordinary distilled water, also water which had been made with much care absolutely pure; in all these samples this same band was visible, and as long as the water was clear, as far as we could judge, it was of the same degree of intensity. A column of water eight feet long shows the band clearer than one only six feet; still greater lengths we have not yet tried. We next tried the effect of increase of temperature on the water. For this purpose the glass tube containing the water was fitted into an air-bath, and the temperature was raised from 20° to 60° without removing the tube from before the spectroscope; no change in the band, either in position or intensity, as far as we could see, occurred. Further, it seemed to us that it would be interesting to try whether, on dissolving different colourless substances in water, the band would be affected. We consequently examined saturated solutions of the following substances in a tube 8 feet long:—Ammonium chloride, ammonium nitrate, ammonium carbonate, potassium nitrate, lead nitrate, sodium chloride, and sugar. In all these cases the band was as visible as in pure water, and no additional band was seen. With a mixture of 1 volume of sulphuric acid and 5 of water the band was unaffected, but if pure commercial hydrochloric acid was examined in a 6-feet tube the band was invisible, but with 8 feet a faint indication of it was seen.

This absorption with water being so marked, we naturally went on to try whether other so-called colourless liquids gave, when depths of 6 or 8 feet of them were examined, absorption bands, and at first really our difficulty was to find any liquid which did not show clearly one or more bands.

The ordinary solution of ammonia gave a very clear and marked spectrum (Fig. 2). It consists of four bands, the centres of which are at 650, 630, 610, and 556. The band at 650 is much the darkest, and the band at 630 is remarkably sharp. Then with regard to the 610 band, it is characterised by sharpness only on the least refrangible side, but shades off gradually on the other side, the shade extending as far as 596; this shade is probably due to the water band; and lastly, the band at 556 is by far the

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[1] Piazzi Smyth, "Edinburgh Astronomical Observations," vol. xiv.

[2] In this and the following experiments a Desaga's spectroscope with a single heavy glass prism was used, and the source of light was an Argand gas-burner. The measurements are expressed in the millionths of a metre.